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Landscape metrics analysis in the proboscis monkey habitat in Kuala Lupak Wildlife Reserve

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Abstract*. Landscape Metrics studies of the proboscis monkey* (Nasalis larvatus) *habitat landscape are still limited in information to estimate the sustainability of their habitat in wetlands. Analysis of the landscape metrics of the proboscis monkey habitat is needed as important information for the preservation of the proboscis monkey habitat, which is experiencing degradation due to land conversion. This study aims to analyze the landscape metric characteristics of proboscis monkey habitat in wetlands. Analyzing the characteristics of the proboscis monkey habitat, Worldview-3 data is needed to obtain information on land use and land cover by means of a GEOBIA-based classification, then analyzed using Fragstat 4.2 to obtain Class Area (CA), Number of Patch (NP), Edge Density (ED) values, Landscape Shape Index (LSI), Mean Patch Size (MPS), and Mean Shape Index (MSI) as the implementation of Proboscis monkey habitat characteristics. The results showed that the landscape of the Kuala Lupak Wildlife Reserve has an area of 4 952.10 hectares consisting of 3 936 patches with an average area of 67 945 hectares/patch and a standard deviation of 409.27. The total edge has an area of 1 191 712.54 meters and a density of 240 648 hectares. The Mean Shape Index has a value of 10.67. The characteristics of the proboscis monkey habitat in the Kuala Lupak Wildlife Reserve illustrate the occurrence of fragmentation of the proboscis monkey's habitat and is not ideal for the protection of proboscis monkeys, because it can lead to isolated pockets of habitat.*

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INTRODUCTION

Proboscis monkey (*Nasalis larvatus*) is an important endemic species for South Kalimantan Province because it is a mascot primate (Muhaimin *et al.*, 2017). The proboscis monkey was chosen as the mascot of South Kalimantan Province because this animal has different characteristics from other primates (Alikodra *et al.*, 2015). Proboscis monkeys are the Colobinae subfamily with the largest size, and proboscis monkeys are sexual dimorphism. They differ in size from males and females (Kern, 1964; Bennett and Sebastian, 1988; Yeager, 1989). Male proboscis monkeys have a body size from body length to head of 73-76 cm (average 75.5 cm) and weight of male proboscis monkeys ±20 kg, while female proboscis monkeys have a body size of 61-64 cm (average 62 cm) and have half the body weight of male proboscis monkeys (Napier and Napier, 1985;

Yeager, 1990). The specific morphology of the proboscis monkey's body is on the nose, like other leaf-monkeys in Asia (*Pygathri*, *Rhinopithecus*, and *Simias*), so this group is referred to as odd-nosed leaf-monkeys (Hutchins *et al.*, 2003).

The size of the canines of the male proboscis monkey is significantly larger than that of the female. A long tail, about half of the head and body length, serves to maintain the balance of the proboscis monkey when moving or when resting on a tree branch (Hutchins *et al.*, 2003). The recognizable characteristics of adult male proboscis monkeys are the large, long hanging nose and genitals colored red with scrotum black, and there is a white shaped triangle in the hips and the development of strong muscles, has membranes on the toes and fingers that are useful when swimming or for walking on muddy soil in mangrove areas. In female proboscis monkeys, the nose is smaller and sharper. Adult proboscis monkeys have light orange and yellowish-brown fur (Napier and Napier, 1985; Murai, 2006).

These animals are included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2019) Appendix I, namely animals that are not allowed to be traded internationally and are included in the list of the Red Book of endangered species: International Union for the Conservation of Nature and Nature Resources (IUCN) as an animal with a depressed population (Boonratana *et al.*, 2021). The proboscis monkey population has experienced a drastic decline due to the continued decline in the quality and quantity of their habitat. The proboscis monkey habitat area is ±29 500 km^2, 40% of which has changed function, and only 4.1% are in conservation areas (McNeely *et al.*, 1990).

Proboscis monkeys are a type of animal that is very sensitive to habitat damage (Suwarto *et al.*, 2016). The proboscis monkey population in Kalimantan was ±114 000 individuals in the span of 10 years (1986-1995); there was a population decline of >50% (Bismark, 2004). Wetlands as a habitat for proboscis monkeys undergo many changes in land use that can lead to extinction (Soendjoto *et al.*, 2002, 2005; Suwarto *et al.*, 2016; Mukhlisi *et al.*, 2018; Sukarelawati, 2021). One of the proboscis monkey habitats in wetlands in South Kalimantan Province is Kuala Lupak Wildlife Reserve (SMKL); even though they are in a protected area, these animals experience disturbances due to human activities in the SMKL area such as settlements, ponds, and encroachment of mangrove forest wood (Rabiati, 2016).

Technology GIS is a potential medium that can help analyze the relationship between animal species and their habitat (Yamada *et al.*, 2003; Scolozzi and Geneletti, 2012). GIS can also contribute to modeling the sustainability of animal habitats (Osborne *et al.*, 2001; Leitão and Ahern, 2002; Bellamy *et al.*, 2013). The spatial configuration of the landscape is an essential factor in determining the sustainability of species' habitat, especially proboscis monkeys (Jacquemyn *et al.*, 2003; Dufour *et al.*, 2006; Vasudev *et al.*, 2015; Muhaimin *et al.*, 2017). Landscape metrics is a widely used tool for patch-based discrete land cover class analysis, which software is currently developing rapidly, getting better and more sophisticated.

One commonly used software for calculating landscape metrics is the FRAGSTATS Software (Mcgarigal and Marks, 1994; Hesselbarth *et al.*, 2019). FRAGSTATS was the first software to provide a broad collection of landscape metrics and subsequently revolutionized the pattern analysis landscape (Kupfer, 2012; Gustafson, 2019; Hesselbarth *et al.*, 2019). The importance of landscape metrics is to understand how landscape characteristics affect ecological processes and the spatial distribution of species (Turner, 1989; Kupfer 2012), one of which analyzes the ecology of the proboscis monkey habitat. As protected and endangered animals, Proboscis monkeys are very important to study. Therefore, a study is needed for the proboscis monkey habitat. This study aims to analyze the characteristics of the proboscis monkey habitat landscape in the Kuala Lupak Wildlife Reserve.

METHOD

Research Location and Time

The research was conducted at the Kuala Lupak Wildlife Reserve, located in the administrative area of Barito Kuala Regency, South Kalimantan Province, with a geographical location of 3º28'03.30"-3º30'01.43"

South Latitude and 114º24'16.41"-114º25'00.13" East Longitude. The research area is ±3 375 ha. Kuala Lupak Wildlife Reserve is one of the proboscis monkey habitats in South Kalimantan. However, habitat degradation due to the conversion of mangroves into aquaculture areas in the Kuala Lupak Wildlife Reserve is a major factor threatening the sustainability of the proboscis monkey population in this area (Rabiati *et al.*, 2016; BKSDA Kalimantan Selatan, 2019). The research area is shown in Figure 1.

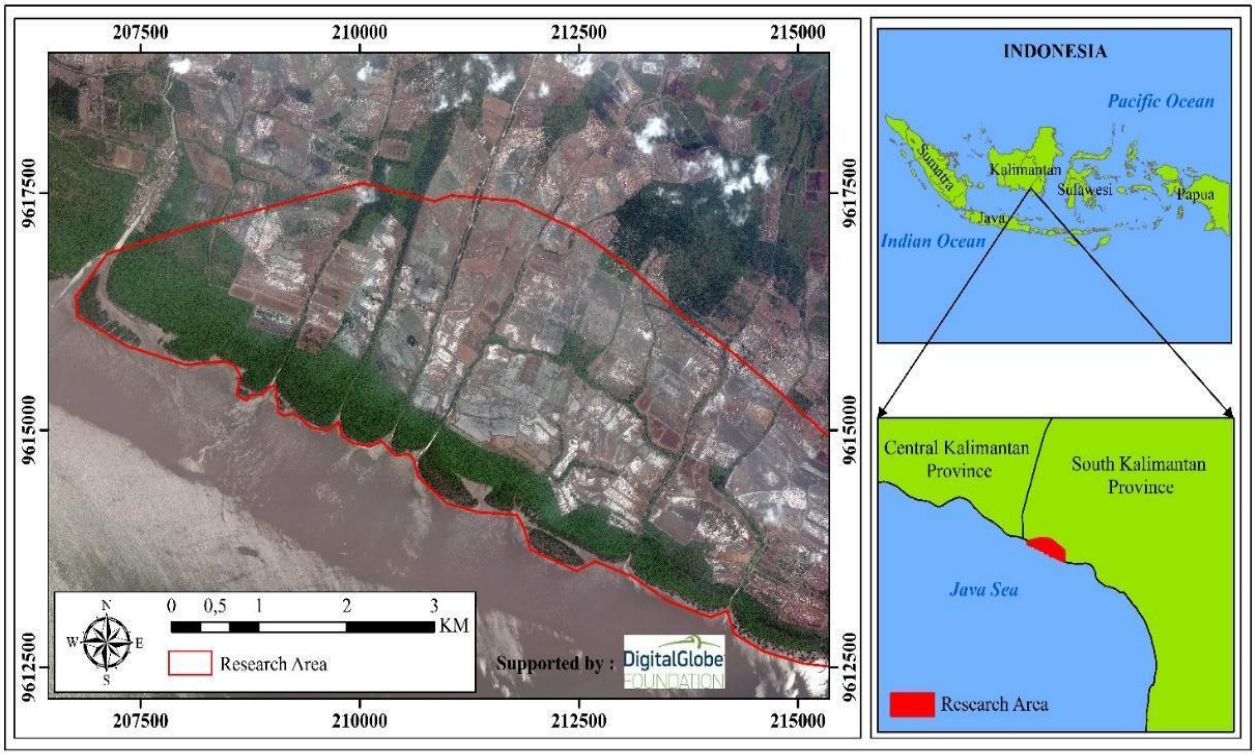

Figure 1 Research location of Kuala Lupak Wildlife Reserve

Data Collection

The data collection stage includes collecting raster and vector spatial data and field data in the form of photos of land cover and land functions at the research location. The data includes Worldview-3 satellite imagery recorded on October 22, 2020, used to analyze land use and cover vegetation, rivers, seas, settlements, ponds, roads, and open land. This image has a spatial resolution of 1.24 meters for multispectral and a spatial resolution of 0.31 meters for panchromatic; besides being a high spatial resolution image, the Worldview-3 image has a relatively high spectral resolution of eight spectral bands. The image used has a cloud cover of 15%, but for the Kuala Lupak Wildlife Reserve study area, there is no cloud cover and cloud shadow, so there is no disturbance in the image processing process.

Although free from cloud cover and shadows, this image needs to be corrected to minimize interference using radiance correction, TOA Reflectance correction, and FLAASH Atmospheric Correction using ENVI 5.3. Field data is used to check the level of truth between the results of image classification and in the field. Direct observation activities and field documentation include recording each location of land cover and land function with cameras and GPS and observing the condition of the natural landscape, which includes natural and artificial appearances. This image needs to be corrected to minimize interference using radiance correction, TOA Reflectance correction, and FLAASH Atmospheric Correction using ENVI 5.3.

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Data Analysis Method

Landscape metrics analysis at the research site was carried out using an ecological approach to the proboscis monkey habitat. This analysis is an approach whose primary goal is to preserve the proboscis monkey habitat, which has been degraded due to land conversion (Iskandar *et al.*, 2017; Muhaimin *et al.*, 2017; Budiono, 2019; Pangestu *et al.*, 2019; Desnindriani, 2020). The description of the method stages in this research include:

Spatial Data Pre-Processing

Image correction

Worldview-3 image correction needs to be done to improve the image quality used in the study. The recording produced by the worldview-3 sensor is inseparable from interference caused by the sensor itself or interference from outside, such as the atmosphere and the sun. Traveling electromagnetic waves through the atmosphere gives rise to the potential for absorption and scattering of energy. This interference makes the resulting spectral values not match the actual conditions. The corrections made include sensor correction, which produces a radiance at sensor image, then atmospheric correction is carried out, which produces an at surface reflectance image. At the same time, geometric correction on the image is not carried out because the image used is level 2A orthorectified data. Atmospheric correction using ENVI 5.3 Software.

$$L = GAIN * DN * \left(\frac{\text{abscal factor}}{\text{effective bandwidth}}\right) + OFFSET \quad (1)$$

Information:

L	=	The top-of-atmosphere radiance
GAIN	=	Radiometric calibration depends on the absolute band factor in Worldview-3. handbook
DN	=	The pixel value in the image.
Abscal factor	=	Radiometric calibration is available in Worldview-3. image metadata
Effective bandwidth	=	Radiometric calibration is available in Worldview-3. image metadata
OFFSET	=	Radiometric calibration depends on the absolute band factor in Worldview-3. handbook

$$\rho_p = \frac{\pi * L\lambda * d^2}{ESUN\lambda * \cos(\theta_s)} \quad (2)$$

Information:

ρ_p	=	Planetary reflectance
$L\lambda$	=	Spectral radiance at the sensor's aperture
$ESUN\lambda$	=	Band dependent mean solar exoatmospheric irradiance
θ_s	=	Solar zenith angle
d	=	Earth-sun distance, in astronomical units

Image masking

Image masking focuses on selecting the research area by covering other areas that are not studied. The process of selecting the study area in this research is by masking the image, which is limited to the area of the Kuala Lupak Wildlife Reserve, as the basis for the study area. The image masking process was carried out

using ENVI 5.3 Software with the masking area based on the boundary vector data of the Kuala Lupak Wildlife Reserve.

Image classification

Land use and land cover maps were created using Worldview-3 imagery with Object-Based Classification Analysis (GEOBIA). A representative and accurate method is needed to extract land use and land cover information as landscape variables. The GEOBIA approach is considered superior to pixel-based classification because it does not only consider spectral aspects but includes spatial information (Hurd *et al.*, 2006; Liu and Xia 2010). GEOBIA, with specifications whose analysis process is based on spectral and spatial appearances, is considered capable of extracting image information with the appearance of objects in high spatial resolution images. Land use and cover classification are divided into seven parts: vegetation, rivers, seas, settlements, ponds, roads, and open land.

Land use and land cover classification based on GEOBIA using Ecognition 10 Software with the coordinate system used is UTM datum WGS 1984 zone 50S. The GEOBIA classification is done simply by using the nearest neighborhood algorithm, which is run on the segmented Worldview-3 image. This classification is based on fuzzy logic and is a supervised classification, so it requires a sample to be used as a training area. Classification is done not only by spectral characteristics but also by geometric input information so that the determination of feature space can improve classification accuracy. The classification stages include segmentation, creating a classification class, training area, determining feature space, and executing classification.

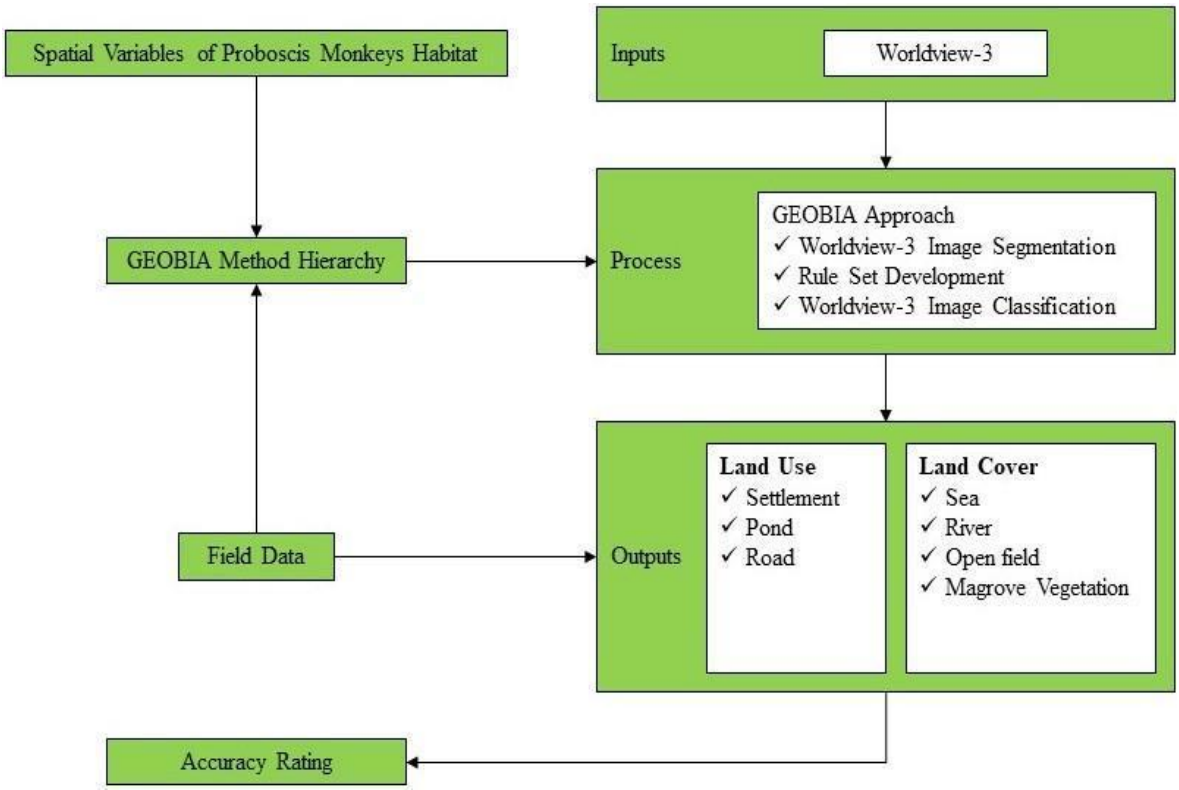

Figure 2 Schematic of land use and land cover classification process using GEOBIA analysis

The land use and land cover classification results are then tested for accuracy using an accuracy test matrix that aims to determine how much accuracy is generated from the GEOBIA-based classification results based on actual conditions in the field. The accuracy test was carried out on each sample unit of land use and land

cover classes to obtain classification accuracy. The accuracy test is only carried out in the sample area and around the sample visited during measurements and field observations. Calculation of accuracy in this study using the online confusion matrix calculator (www.marcovanetti.com/pages/cfmatrix/). The schema of the land use and land cover classification process using GEOBIA analysis is shown in Figure 2.

Landscape Metrics Analysis

Metrics analysis of the landscape using land use and land cover maps from the results of the GEOBIA classification analysis in the Kuala Lupak Wildlife Reserve. The Metrics analysis parameter of the landscape consists of seven components, including mangrove vegetation, rivers, seas, settlements, ponds, roads, and open land. The Metrics analysis of the proboscis monkey habitat landscape is divided into six index groups, including Class Area (CA), Number of Patch (NP), Edge Density (ED), Landscape Shape Index (LSI), Mean Patch Size (MPS), and Mean Shape Index (MSI) (Haila, 2002; Prasetyo, 2017). The software used to analyze landscape metrics is Fragstats 4.2.

RESULTS AND DISCUSSION

Land Use and Land Cover Analysis

Classification of land use and land cover analyzed by the Geobia method from Worldview-3 imagery consists of land use classes for settlements, ponds, and roads. At the same time, the land cover class consists of vegetation, rivers, seas, and open land. The results of this classification map are then evaluated using the overall accuracy and Kappa Accuracy Techniques (Congalton, 2001). The calculation of mapping accuracy using the confusion matrix online calculator (Vanetti, 2007) resulted in the overall accuracy of land use and land cover mapping in the Kuala Lupak Wildlife Reserve, 98.13%, while the Kappa coefficient is 0.97. The accuracy value is high, which indicates that the land use and land cover maps are accurate and follow actual conditions in the field (Khoiriah and Farda, 2012). Examples of segmentation samples on several land cover and land use objects and GEOBIA-based classification maps are shown in Figure 3. The mapping accuracy of land use and land cover in Kuala Lupak Wildlife Reserve is shown in Table 1.

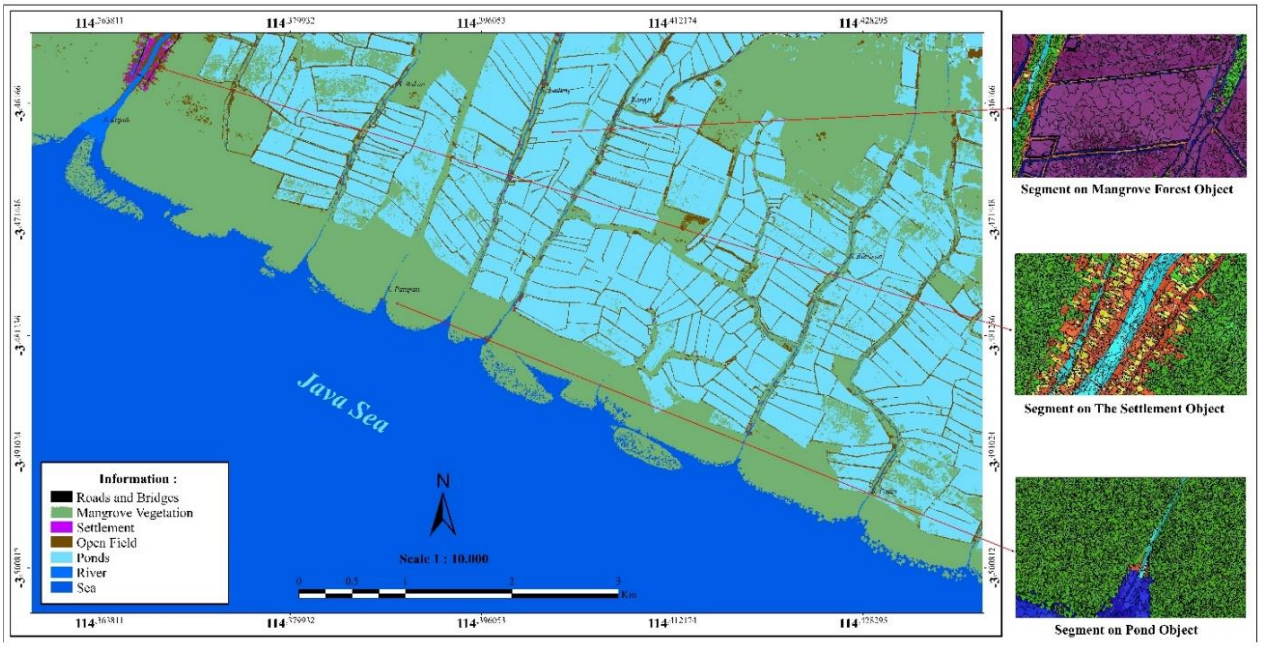

Figure 3 Examples of segmentation samples on several land cover and land use objects as well as GEOBIA based classification maps

Table 1 Mapping accuracy of land use and land cover in Kuala Lupak Wildlife Reserve

Class	Settlement	Pond	Road	Sea	River	Open Field	Mangroves Vegetation	Overall Classification	Producer Accuracy (Precision) (%)
Settlement	20							20	100
Pond		25				2		27	92.59
Road			1					1	100
Sea				1				1	100
River					8			8	100
Open Field						10		10	100
Mangrove Vegetation							40	40	100
Truth Overall	20	25	1	1	8	12	40	107	
User Accuracy (Recall) (%)	100	100	100	100	100	83.33	100		

Analysis of Landscape Metrics in the Proboscis Monkey Habitat at the Kuala Lupak Wildlife Reserve

Land use and land cover classes represented the metrics analysis of the proboscis monkey habitat landscape consisting of patch, corridor, and matrix types. The patch is a non-linear surface area that differs in appearance from the surrounding area and is the basic unit of a landscape (Prastiyo *et al.*, 2017). A corridor is a homogeneous surface area that is long and continuous (connectivity) (Prastiyo *et al.*, 2017). Matrix is the most dominant surface area of landscape mosaic, a landscape element, and has a dominant role in the landscape (Forman and Godron, 1986; Narmada *et al.*, 2021). The metrics elements of the landscape are analyzed for quantity using landscape ecological parameters consisting of area measurements, namely the total Class Area (CA), measures of density and variability, namely the Number of Patch (NP), edge size, namely Edge Density (ED), and shape sizes, namely Landscape Shape Index (LSI), Mean Patch Size and Mean Shape Index. The landscape ecological parameters mentioned above can represent the landscape metrics analysis in a habitat (Narmada *et al.*, 2021), including the proboscis monkey habitat in the Kuala Lupak Wildlife Reserve.

Table 2 Results of landscape level analysis in Kuala Lupak Wildlife Reserve

No									
	1	CA	NP	PD	LPI	TE	ED	LSI	AREA_MN
		4 952.10	3 936	79.48	61.73	1 191 712.58	240.65	168.90	67.94
	2	AREA_MD	AREA_SD	AREA_CV	SHAPE_MN	SHAPE_AM	FRAC_MN	FRAC_AM	PARA_MN
		0.50	409.26	3 310.01	10.68	28.25	9.26	10.05	14 854.73

Description: Class Area (CA), Number of Patches (NP), Patch Density (PD), Largest Patch Index (LPI), Total Edge (TE), Edge Density (ED), Landscape Shape Index (LSI), Mean Patch Size (AREA_MN), Median Patch Area (AREA_MD), Standard Deviation Patch Area (AREA_SD), Coefficient of Variation Patch Area (AREA_CV), Mean Shape Index (SHAPE_MN), Area Weighted Mean Shape Index (SHAPE_AM), Mean Fractal Dimension Index (FRAC_MN), Area Weighted Mean Fractal Dimension Index (FRAC_AM), Mean Perimeter-Area Ratio (PARA_MN).

The Kuala Lupak Wildlife Reserve landscape has an area of 4 952.10 hectares consisting of 3 936 patches with an average area of 67.94 hectares/patch and a standard deviation of 409.26. The total edge has an area of 1 191 712.58 meters and a density of 240.65 hectares. The average shape index (Mean Shape Index) has a value of 10.67. The outstanding value of the average shape index (Mean Shape Index) is 1 with a square shape; if it exceeds the ideal limit, then the shape becomes irregular (Horodnic *et al.*, 2019). The higher the Mean Shape Index value, the more edges it has (Kaban *et al.*, 2017), unsuitable for the Kuala Lupak Wildlife Reserve. The metrics analysis results of the landscape in the Kuala Lupak Wildlife Reserve are shown in Table 2.

At the level of analysis of class landscape metrics in the Kuala Lupak Wildlife Reserve, the parameters used include: total Class Area (CA), density, and variability measures, namely Number of Patch (NP), edge size, is Edge Density (ED), and shape sizes are Landscape Shape Index (LSI), Mean Patch Size and Mean Shape Index. These parameters were used to assess the landscape structure of the proboscis monkey habitat shown in Table 3.

Table 3 Results of analysis of landscape structure on a class level in the Kuala Lupak Wildlife Reserve

No	Type	Pond	Mangrove Vegetation	Open field	Settlement	River	Street	Sea	TOTAL
1	CA	1 444.18	1 220.78	132.74	4.43	29.07	0.49	2 120.4	4 952.10
2	NP	1 689	505	1 431	45	219	8	39	3 936.00
3	PD	34.11	10.20	28.89	0.91	4.42	0.16	0.79	79.48
4	LPI	4.69	13.96	0.1	0.01	0.20	0.01	42.76	61.73
5	TE	608 086.8	301 257.7	197 841.9	6 836.67	34 272.17	821.30	42 596.04	1 191 712.58
7	ED	122.79	60.84	39.95	1.38	6.92	0.17	8.60	240.65
8	LSI	72.98	22.03	43.03	8,16	15.80	3.83	3.07	168.90
9	Area_Mn	10.72	2.42	0.09	0.10	0.13	0.11	54.37	67.94
10	Area_Md	0.15	0.05	0.05	0.05	0.05	0.10	0.05	0.50
11	Area_Sd	40.09	33.53	0.18	0.10	0.68	0.02	334.66	409.26
12	Area_Cv	460.47	1 387.04	198.84	101.65	511.34	35.14	615.53	3 310.01
13	Shape_Mn	2.90	1.24	1.10	1.16	1.13	2.05	1.10	10.68
14	Shape_Am	9.96	8.52	1.53	1.44	1.92	2.07	2.81	28.25
15	Frac_Mn	2.09	1.04	1.02	1.04	1.03	2.02	1.02	9.26
16	Frac_Am	2.36	1.26	1.08	1.09	1.11	2.03	1.12	10.05
17	Para_Mn	3 039.02	1 583.42	1 694.07	1 708.27	1 691.62	3 539.73	1 598.60	14 854.73

Description: Class Area (CA), Number of Patches (NP), Patch Density (PD), Largest Patch Index (LPI), Total Edge (TE), Edge Density (ED), Landscape Shape Index (LSI), Mean Patch Size (AREA_MN), Median Patch Area (AREA_MD), Standard Deviation Patch Area (AREA_SD), Coefficient of Variation Patch Area (AREA_CV), Mean Shape Index (SHAPE_MN), Area Weighted Mean Shape Index (SHAPE_AM), Mean Fractal Dimension Index (FRAC_MN), Area Weighted Mean Fractal Dimension Index (FRAC_AM), Mean Perimeter-Area Ratio (PARA_MN)

Class Area (CA)

The results of the Class Area analysis show the extent of each land use and land cover in the Kuala Lupak Wildlife Reserve (Mcgarigal and Marks, 1994); it is known that the landscape structure consists of 3 land use classes and four land covers.

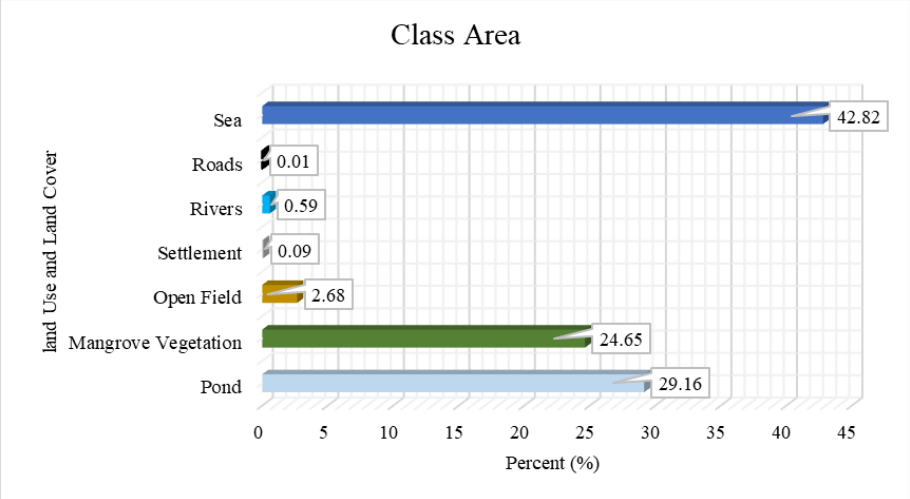

Figure 4 Compilers of the landscape of the Kuala Lupak Wildlife Reserve based on class area analysis

The sea dominates the research location by 42.82% because it is on the southern coast of South Kalimantan Province, while the river is 0.59%. The area of mangrove forest, which is the habitat of proboscis monkeys, is 24.65%. This habitat area also has disturbance parameters that reduce the quality and quantity of the proboscis monkey habitat landscape structure, including ponds having an area of 29.16%, settlements having an area of 0.09%, and roads having an area of 0.01%, and open land having an area of 2.68%. These disturbance parameters pose a threat to the sustainability of Proboscis monkeys (Suwarto *et al.*, 2016). *Lutung* or *Hirangan* (*Trachypithecus cristatus*) and Long-tailed Ape (*Macaca fascicularis*) (Aryadi and Satriadi 2015). The preparation of the landscape of the Kuala Lupak Wildlife Reserve based on the class area analysis is shown in Figure 4.

Number of Patches (NP)

The number of Patch's is a simple measure of the subdivision level or fragmentation of the patch type. The NP class level shows the number of patches in each class; the number of patches informs the fragmentation of habitat (Mcgarigal and Marks, 1994). The results of the NP analysis of pond land use classes in the Kuala Lupak Wildlife Reserve have the most significant number of patches, namely 42.91%, then open land by 36.36%, mangrove forests by 12.83%, rivers by 5.56%, settlements by 1.14%, sea by 0.99% and road by 0.20%. The greater the patch value, the more fragmentation an environmental parameter is. Mangrove forest, the habitat of proboscis monkeys, has a value of 12.83% or 505 patches, with an average area of each patch of 2.4174 ha. This shows that the condition of the Kuala Lupak Wildlife Reserve is very fragmented and less than ideal for proboscis monkey protection because it can lead to isolated pockets of habitat (Haila, 2002; Alikodra *et al.*, 2015). The graph of patches for each class in the Kuala Lupak Wildlife Reserve is shown in Figure 5.

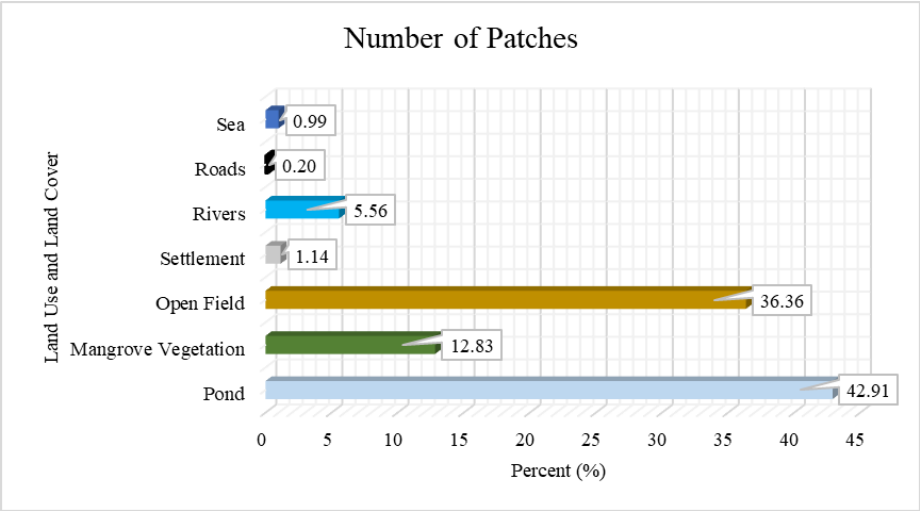

Figure 5 Graph of the number of patches for each class at the Kuala Lupak Wildlife Reserve

Edge Density (ED)

Edge density is used to measure the size of the shape of a patch. Edge density is equal to the sum of the lengths of all edge segments involving the patch type or represents the ratio between the lengths of all the different class boundaries in a landscape to the total area under study (Mcgarigal and Marks, 1994), for example when a landscape is a mosaic of a type such as mangrove vegetation is adjacent to a pond. The edge is the location where the two types join. Edge density is used to determine the area favored by animals. Animals like edge areas are very fond of areas with high edge density and vice versa (Sumarto *et al.*, 2012). The results of the analysis show that the most significant edge density is found in the pond land-use class, which is 51.03%

or 122.79 ha, sea by 3.57% or 8.60 ha, rivers by 2.88% or 6.92 ha, settlements by 0.57% or 1.38 ha, roads by 0.07% or 0.16 ha.

Habitat parameters that support the existence of proboscis monkeys and their living environment, namely mangrove forests have a significant edge density value of 25.28% or 60.83 ha; this shows that mangrove forest areas have borders with other types of landscape classes such as sea, ponds, open land, rivers, and settlement. As a wild animals, proboscis monkeys do not like habitat areas bordering the class type of environmental parameters that interfere with their habitat except rivers because they are a source of drinking water. This is based on researchers' observations in the field; proboscis monkeys tend to like mangrove forests bordering rivers (Mukhlisi *et al.*, 2018). The edge density graphite of the Kuala Lupak Wildlife Reserve is shown in Figure 6.

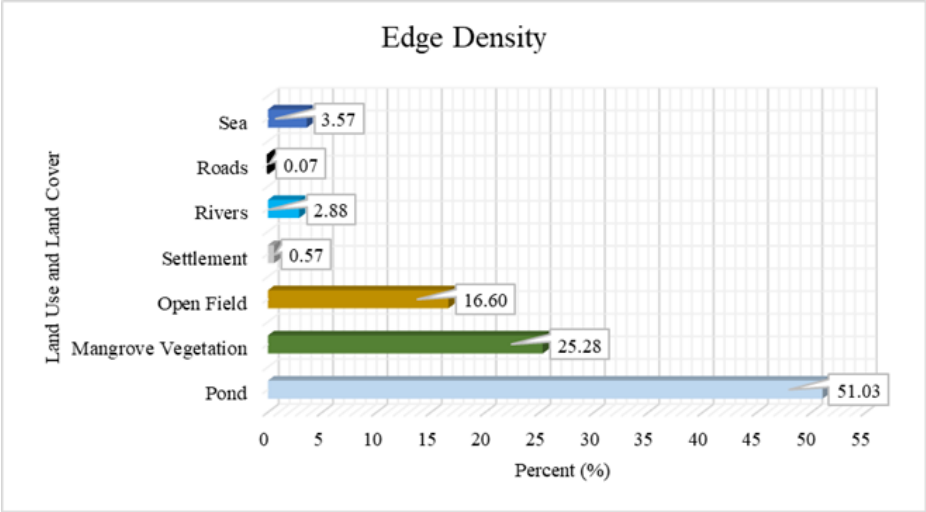

Figure 6 Edge density graph for each class at the Kuala Lupak Wildlife Reserve

Landscape Shape Index (LSI)

The Landscape Shape Index is an alternative to the patch shape index, based on the average of the patch characteristics at the grade and landscape level. This index measures the perimeter ratio for the landscape (Herzog and Lausch, 2001). The LSI value is equal to 1 when the landscape consists of a single circular (vector) or square (raster) patch; the more significant the LSI value, the more irregular the landscape shape or the increased edge length in a landscape (Gyenizse *et al.*, 2014; Ramdhan, 2015; Prastiyo *et al.*, 2017). The results of the analysis show that the most extensive landscape shape index is in the pond land-use class, which is 72.98, then the land cover in the form of open land has a value of 43.03, mangrove forest land cover is 22.03, rivers are 15.80, settlements are 8.16, roads are 3.83, and the sea is 3.07.

Habitat parameters that support the survival of proboscis monkeys, namely mangrove forests, have a considerable LSI value of 22.03; this shows that the mangrove forest area has an irregular shape and the length of the edges increases in a landscape. The considerable LSI value in mangrove forest areas is caused by land clearing for ponds and mangrove forest areas which are separated by several rivers so that they have an irregular shape, which can cause the proboscis monkey habitat pockets to be separated from the primary habitat (Haila, 2002; Aryadi and Satriadi, 2015; Muhaimin *et al.*, 2017). The landscape shape index graph at the Kuala Lupak Wildlife Reserve shows that the mangrove forest area has an irregular shape. The length of the edges increases in a landscape.

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The landscape shape index graph at the Kuala Lupak Wildlife Reserve is shown, which can cause pockets of proboscis monkey habitat to separate from the primary habitat (Haila, 2002; Aryadi and Satriadi, 2015; Muhaimin *et al.*, 2017). The landscape shape index graph at the Kuala Lupak Wildlife Reserve is shown, which can cause the proboscis monkey habitat pockets to separate from the primary habitat (Haila, 2002; Aryadi and Satriadi, 2015; Muhaimin *et al.*, 2017). The landscape shape index graph at the Kuala Lupak Wildlife Reserve is shown in figure 7.

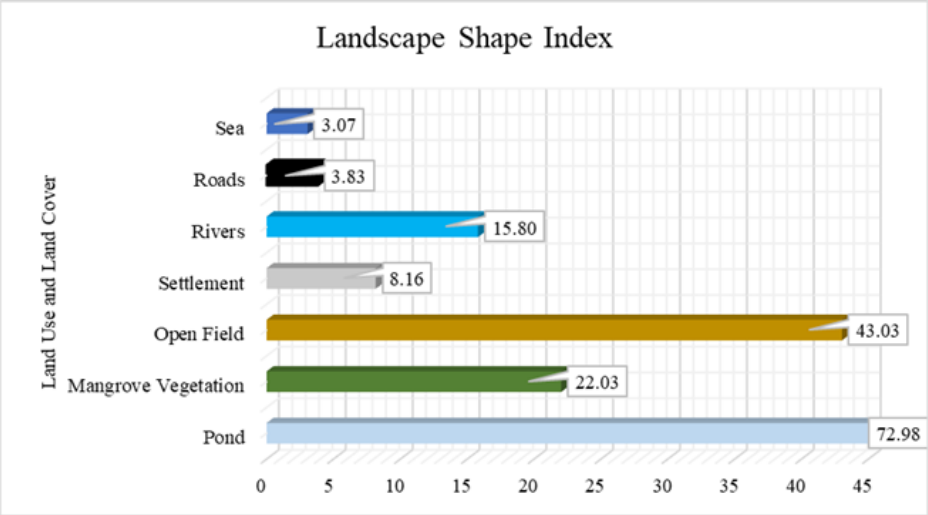

Figure 7 Landscape shape index graph for each class at the Kuala Lupak Wildlife Reserve

Mean Patch Size

Mean Patch Size analysis measures the habitat area in the Kuala Lupak Wildlife Reserve. Patch size indicates one metric to determine whether a landscape is fragmented or not; patches with a significant value indicate how small it is fragmented (Mcgarigal and Marks, 1994). If the mean patch size is small, the fragmentation in the field increases, and if the mean patch size is large, the fragmentation in the field decreases. The mean patch size can indicate the number of species living in a habitat (Kaban *et al.*, 2017).

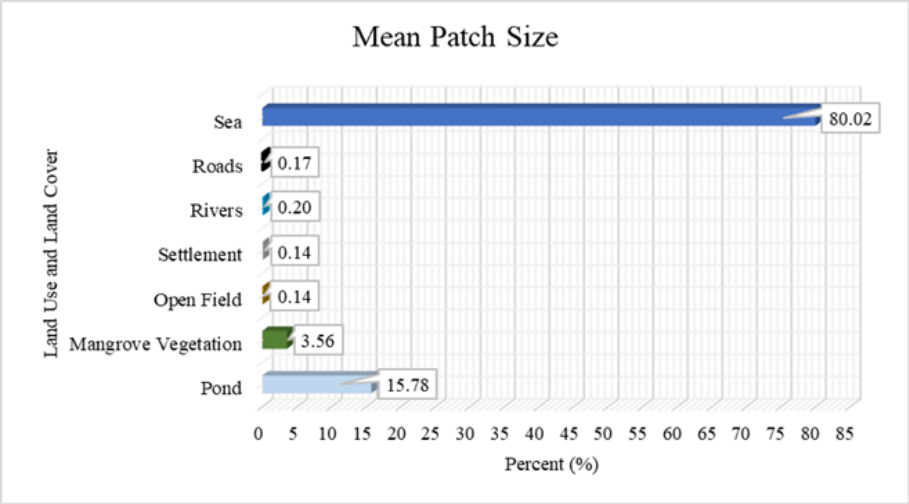

Figure 8 Graph of the mean patch size for each class in the Kuala Lupak Wildlife Reserve

The mean patch size analysis results show that the marine land cover class has the highest value, namely 80.02%, with a significant value indicating that the marine area is not fragmented. While the habitat parameter that supports the sustainability of proboscis monkeys, namely mangrove forests, has a minimal Mean Patch Size value of 3.56%, the mangrove forest area is very fragmented. The mean patch size value is added from the habitat disturbance parameter, which increases in the class of ponds, settlements, open land, and road (Suwarto *et al.*, 2016). The graph of the Mean Patch Size for each class in the Kuala Lupak Wildlife Reserve is shown in Figure 8.

Mean Shape Index

The mean shape index analysis aims to obtain a landscape metric parameter to describe the complexity of the patch shape. A mean shape index value greater than one indicates that the patch or habitat parameter class is irregular, while a mean shape index value equal to 1 indicates that the patch or habitat parameter class is circular (perimeter) or square (Mcgarigal and Marks, 1994; Wang *et al.*, 2014). The results of the analysis of the mean shape index of the pond land-use class have the highest value of 2.90; roads have a value of 2.05, mangrove forests have a value of 1.24, settlements have a value of 1.16, rivers have a value of 1.13, open land and sea have a mean shape value. The same index is equal to 1.10. All land use and land cover classes in the Kuala Lupak Wildlife Reserve can be categorized into two categories, namely regular circular or square shapes consisting of road parameters, open land, sea, rivers, settlements, and mangrove forests. While irregular or complex shapes are found in the pond's environmental parameters. The graph of the mean-shape index for each land cover class in the Kuala Lupak Wildlife Reserve is shown in Figure 9.

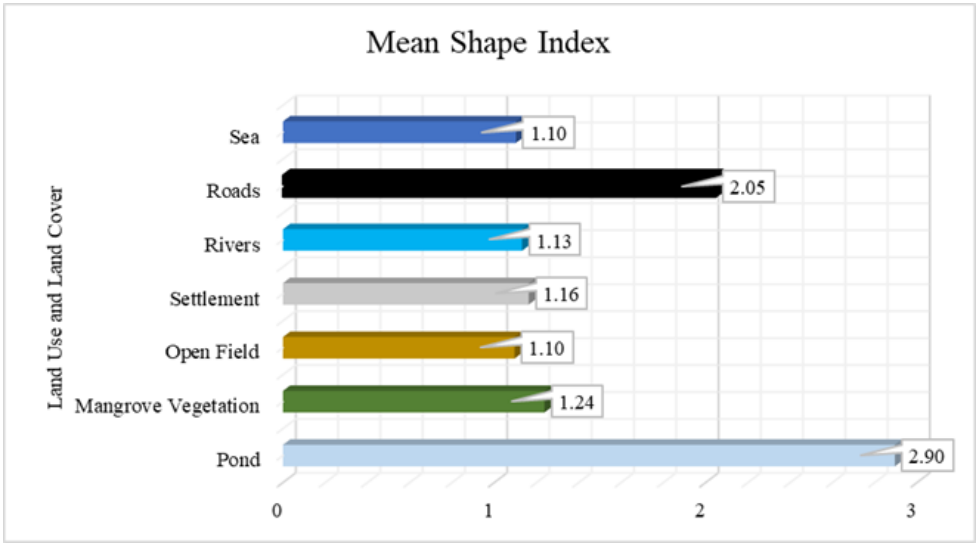

Figure 9 Graph of mean shape index for each land cover class in Kuala Lupak Wildlife Refuge

CONCLUSION

The proboscis monkey (*Nasalis larvatus*) habitat in the Kuala Lupak Wildlife Reserve identified was the mangrove forest which has an area of 24.65% of the total area of 4 952.75 hectares. The mangrove forest, which is the habitat of the proboscis monkey, has a patch value of 12.83% or 505 patches with an average of 2.41 for each patch; this value indicates the condition of the wetland area of the Kuala Lupak Wildlife Reserve is very fragmented and not ideal for proboscis monkey protection. The edge density of mangrove forest in Kuala Lupak Wildlife Reserve has a value of 25.28%, or 60.83 hectares, indicating that the mangrove forest area has borders with other landscape types such as sea, ponds, open land, rivers, and settlements. As wild animals, proboscis monkeys do not like habitat areas bordering the class type of environmental parameters that interfere with their habitat except rivers because they are a source of drinking water. The value of the landscape

shape index of the mangrove forest as a proboscis monkey habitat has a significant value of 22.03, indicating that the mangrove forest area has an irregular shape.

Meanwhile, the mean value of the mangrove forest patch size is minimal, 3.56%, indicating that the mangrove forest area is very fragmented. The results of this study reveal that the proboscis monkey habitat in the Kuala Lupak Wildlife Reserve has been degraded due to anthropogenic activities, so further conservation efforts are needed for the better preservation of this species. The value of the landscape shape index of the mangrove forest as a proboscis monkey habitat has a significant value of 22.03, indicating that the mangrove forest area has an irregular shape. Meanwhile, the mean value of the mangrove forest patch size is minimal, 3.56%, indicating that the mangrove forest area is very fragmented.

The results of this study reveal that the proboscis monkey habitat in the Kuala Lupak Wildlife Reserve has been degraded due to anthropogenic activities, so further conservation efforts are needed for the better preservation of this species. The value of the landscape shape index of the mangrove forest as a proboscis monkey habitat has a significant value of 22.03, indicating that the mangrove forest area has an irregular shape. Meanwhile, the mean value of the mangrove forest patch size is minimal, 3.56%, indicating that the mangrove forest area is very fragmented. The results of this study reveal that the proboscis monkey habitat in the Kuala Lupak Wildlife Reserve has been degraded due to anthropogenic activities, so further conservation efforts are needed for the better preservation of this species.

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